CERTIFICATION

I, Hisae OTA, 1-22-18-201, Seta, Setagaya-ku, Tokyo, Japan hereby declare that I am the translator of the following application and certify that the translation is correct and accurate to the best of my knowledge and belief:

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Signature of Translator:

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[Title of the Invention]

METHOD FOR MANUFACTURING FLAT PANEL DISPLAY DEVICE, AND FLAT PANEL DISPLAY DEVICE

[Scope of Claims]

[Claim 1] A method of manufacturing a flat panel display device, comprising:

depositing a getter film on a faceplate that has a phosphor layer formed on a substrate; and

disposing the faceplate, on which the getter film is deposited, and a rear plate, which has an electron source formed on a substrate, faced to each other with a gap therebetween, and hermetically sealing the gap.

[Claim 2] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein the getter film is made of evaporable getter material.

[Claim 3] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein the getter film is substantially made of Ba.

[Claim 4] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein the faceplate comprises a metal back layer on the phosphor layer.

[Claim 5] The method of manufacturing a flat panel display device as set forth in claim 1, further comprising:

heating and deaerating the faceplate, before depositing the getter film.

[Claim 6] The method of manufacturing a flat panel display device as set forth in claim 1, further comprising:

heating and deaerating the rear plate, before hermetically sealing.

[Claim 7] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein each of the processes is implemented in a vacuum atmosphere.

[Claim 8] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein each of the processes is implemented in the same manufacturing apparatus continuously and/or simultaneously.

[Claim 9] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein each of the processes is implemented in a manufacturing apparatus independent for each of the processes continuously and/or simultaneously.

[Claim 10] The method of manufacturing a flat panel display device as set forth in claim 9:

wherein manufacturing apparatuses independent for each of the processes are arranged so that the faceplate and the rear plate are not exposed to an oxidizing atmosphere.

[Claim 11] The method of manufacturing a flat panel display device as set forth in claim 1 or 2:

wherein in the depositing the getter film on the faceplate, the getter film substantially made of Ba is formed by vapor depositing Ba on the metal back layer of the faceplate in a vacuum atmosphere, the faceplate having the phosphor layer and the metal

back layer formed on the substrate.

[Claim 12] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein the getter film is deposited on at least a part of an image display area of the faceplate.

[Claim 13] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein the getter film is deposited mainly in an area other than an area where the phosphor layer is formed.

[Claim 14] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein the getter film has a thickness of 1 μm or more.

[Claim 15] The method of manufacturing a flat panel display device as set forth in claim 1:

wherein the disposing the faceplate and the rear plate faced to each other with a gap therebetween and the hermetically sealing, is hermetically sealing the gap between the faceplate and the rear plate through a support frame.

[Claim 16] The method of manufacturing a flat panel display device as set forth in claim 15:

wherein the support frame and the faceplate are hermetically sealed by means of indium and/or alloy thereof.

[Claim 17] The method of manufacturing a flat panel display device as set forth in claim 7:

wherein a region between the faceplate and the rear plate is made a degree of vacuum of 1 x 10^{-5} or better by means of a vacuum atmosphere during the process and the getter film.

[Claim 18] The method of manufacturing a flat panel

display device as set forth in claim 1:

wherein each of the processes is implemented in a vacuum atmosphere of 1×10^{-4} Pa or better.

[Claim 19] A flat panel display device, comprising:

a faceplate having a phosphor layer and a metal back layer, and a getter film, the phosphor layer and the metal back layer being formed on a substrate, the getter layer being substantially made of Ba and being deposited on the metal back layer; and

a rear plate having an electron source;

wherein the faceplate and the rear plate are disposed so that face to each other with a gap therebetween, and hermetically sealed.

[Claim 20] The flat panel display device as set forth in claim 19:

wherein the getter film is deposited on at least a part of an image display area of the faceplate.

[Claim 21] The flat panel display device as set forth in claim 19:

wherein the getter film is deposited mainly on an area other than an area where the phosphor layer is formed of the metal back layer.

[Claim 22] The flat panel display device as set forth in claim 19:

wherein the getter film, substantially consisting of the Ba, has a thickness of 1 μm or more.

[Claim 23] The flat panel display device as set forth in claim 19:

wherein the faceplate and the rear plate are hermetically

sealed through a support frame so that forms a gap therebetween.

[Claim 24] The flat panel display device as set forth in claim 23:

wherein the support frame and the faceplate are hermetically sealed by means of indium and/or alloy thereof.

[Claim 25] The flat panel display device as set forth in claim 19:

wherein a region between the faceplate and the rear plate is evacuated to a degree of vacuum of 1×10^{-5} Pa or better.

[Claim 26] A flat panel display device, manufactured by depositing a getter film on a faceplate, which has at least a phosphor layer formed on a substrate, and by disposing the faceplate, on which the getter film is deposited, and a rear plate, which has an electron source formed on a substrate, so as to form a gap therebetween, followed by hermetically sealing the gap.

[Claim 27] The flat panel display device as set forth in claim 26:

wherein the getter film is one formed of evaporable getter material.

[Claim 28] The flat panel display device as set forth in claim 26:

wherein the getter film is substantially made of Ba.

[Claim 29] The flat panel display device as set forth in claim 26:

wherein the faceplate comprises a metal back layer on the phosphor layer.

[Claim 30] The flat panel display device as set forth in claim 26:

wherein, heating and deaerating of the faceplate is implemented before depositing the getter film.

[Claim 31] The flat panel display device as set forth in claim 26:

wherein the getter film is deposited at least in a part of an image display area of the faceplate.

[Claim 32] The flat panel display device as set forth in claim 26:

wherein the getter film is deposited mainly in an area other than an area where the phosphor layer is formed.

[Claim 33] The flat panel display device as set forth in claim 26:

wherein the getter film has a thickness of 1 μm or more.

[Claim 34] The flat panel display device as set forth in claim 26:

wherein the disposing the faceplate and the rear plate faced to each other with a gap therebetween and the hermetically sealing, is hermetically sealing the gap between the faceplate and the rear plate through a support frame.

[Claim 35] The flat panel display device as set forth in claim 34:

wherein the support frame and the faceplate are hermetically sealed by means of indium and/or alloy thereof.

[Claim 36] The flat panel display device as set forth in claim 26:

wherein the gap between the faceplate and the rear plate is evacuated to a degree of vacuum of 1×10^{-5} Pa or better.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a method for manufacturing a flat panel display device that uses an electron emitter such as a field emission cold cathode or the like, and a flat panel display device.

[0002]

[Related Art]

Recently, by making use of, for instance, advanced semiconductor machining technology, field emission cold cathodes have been under active study and have been forwarded to apply in flat panel display devices. A flat panel display device comprises a substrate (rear plate), in which a number of field emission type electron emitters are formed as electron sources on the substrate, and a faceplate, consisting of a glass substrate or the like, on which a phosphor layer is formed. These are oppositely disposed to each other, with a predetermined spacing therebetween. Such a flat panel display device, which uses field emission type electron emitters, is self-emitting different from liquid crystal displays, and may dispense with a backlight. Accordingly, on the basis that the backlight and so on are not necessary, lower power consumption may be attained, a broader field angle may be obtained, and a higher response speed may be attained, in the flat panel display devices.

[0003]

In the flat panel display device that uses the field emission type electron emitter, a volume of a vacuum vessel, which

is formed of the rear plate, the face plate, and support frames, becomes remarkably smaller in comparison with that of an ordinary CRT. Despite the above, an area of wall surface that releases gas does not decrease. As a result, when an amount of gas comparable with that of the CRT is released, a pressure increase in the vacuum vessel becomes extremely high. From the above circumstances, getter material plays a particularly important role in the flat panel display device. However, the getter material, which is electrically conductive, is restricted in positions to deposit, from a point of view of preventing short circuit of wiring or the like.

[0004]

To the aforementioned points, it is proposed to dispose the getter material in a periphery portion, which is outside an image display area of the vacuum vessel, and to form a getter film in the periphery that does not adversely affect on the image display area (Japanese Published Patent Application Nos. HEI 5-151916 JP-A, HEI 4-289640 JP-A, and so on). However, due to such method of disposing the getter film, the getter film formed at the periphery may not effectively absorb the gas released in the image display area. Accordingly, there occurs a problem that a high vacuum may not be maintained over a long period in the vacuum vessel.

[0005]

From the aforementioned circumstances, it is under study to deposit the getter film in the image display area. To this, Japanese Published Patent Application No. HEI 9-82245 JP-A, for instance, discloses as follows. That is, getter material,

consisting of Ti, Zr or alloys thereof, is deposited on a metal back layer formed on the phosphor layer of the faceplate in one way. In another way, the metal back layer itself is formed of one of the aforementioned getter materials. In still another way, in the image display area, the aforementioned getter material is deposited in a portion other than that of electron emitters of the rear plate.

[0006]

[Problems to be Solved by the Invention]

However, in the flat panel display device disclosed in the aforementioned Japanese Published Patent Application No. HEI 9-82245 JP-A, the getter material is deposited in the ordinary panel process. As a result, the getter material is inevitably oxidized of its surface. Since the getter material is particularly important of its degree of surface activity, the surface oxidized getter material may not exhibit a satisfying gas sorption effect.

[0007]

To this, in the aforementioned publication, it is disclosed that after a space between the faceplate and the rear plate is hermetically sealed through the support frame, and thereby a vacuum vessel is formed, an electron beam or the like is irradiated onto the getter material to activate. However, such method cannot effectively activate the getter material. In particular, when the getter material is activated after the formation of the vacuum vessel, gaseous components, such as oxygen or the like, which are liberated in the process of activation, stick to the electron emitter and the other members. As a result, at this stage,

electron emissivity or the like is liable to deteriorate.

[0008]

Furthermore, the getter materials, made of Ti, Zr or the alloys thereof, of which the aforementioned Japanese Published Patent Application No. HEI 9-82245 JP-A mainly describe, have problems that function thereof itself is low. Accordingly, in the flat panel display devices, which operate in the neighborhood of room temperature or at a little higher temperature than that, a sufficient getter function may not be obtained. In the aforementioned Patent Publication, it is also disclosed that, as the getter material, evaporable getter materials such as alloys essentially consisting of Ba can be applicable.

[0009]

However, since the evaporable getter materials are alloys in this configuration, sufficient gettering action may not be obtained, in the flat panel display device that operates in the neighborhood of room temperature or at a little higher temperature than that. Furthermore, if the Ba is evaporated and a Ba film is formed, it may be extremely difficult to suppress for the getter film to stick onto unnecessary portions. As a result, short circuit of wiring or the like is liable to occur. In addition, a reinforcement plate is ordinarily disposed between the faceplate and the rear plate. When the getter material sticks onto such reinforcement plate, however, the short circuit may occur between an electron emitter on a cathode side and a phosphor layer on an anode side, resulting in an occurrence of driver breakdown or lighting failure.

[0010]

Accordingly, the aforementioned Japanese Published Patent Application No. Hei 9-82245 JP-A states that, when employing the evaporable getter, as a device to prevent the wiring from short-circuiting, it is necessary to restrict a direction into which vapor of the getter material sputters, when the evaporable getter is heated. Thus, a particular configuration becomes necessary, resulting in a further complicated device.

[0011]

When the evaporable getter film, consisting of an alloy film or the like of which primary component is Ba, is formed in the course of ordinary panel process, similarly as the getter material, consisting of Ti, Zr, or alloy thereof, the getter film is oxidized more rigorously. Accordingly, it is far from exhibiting function as the getter film.

[0012]

The present invention is carried out to overcome these problems. The object of the present invention is to provide a method for manufacturing a flat panel display device, and a flat panel display device itself. Here, in the method for manufacturing the flat panel display device, an evaporable getter film of excellent getter function is deposited in an image display area in a vacuum vessel, which is formed of a faceplate, a rear plate, and a support frame, while maintaining activity, thereby, the inside of the vacuum vessel, as an envelope, is made possible to maintain a high vacuum state.

[0013]

[Means for Solving the Problems]

A method for manufacturing a flat panel display device of

the present invention, as set forth in claim 1, includes at least depositing a getter film on a faceplate, which has a phosphor layer formed on a substrate, and disposing a faceplate, on which the getter film is formed, and a rear plate, which has an electron source formed on the substrate, faced to each other so as to form a gap therebetween, followed by hermetically sealing.

[0014]

In the method for manufacturing the flat panel display device of the present invention, the getter film is formed of evaporable getter material, as set forth in claim 2, and, furthermore essentially formed of Ba, as set forth in claim 3. Furthermore, the faceplate has a metal back layer on the phosphor layer, for instance, and, the getter film is deposited on the metal back layer, in this case.

[0015]

In the present method for manufacturing the flat panel display device, as set forth in claim 5, preceding the formation of the getter film, heating and deaerating the faceplate is preferably implemented. By implementing the heating and deaerating, gaseous components in the faceplate can be removed, and thereby an intended degree of vacuum in the flat panel display device may be easily attained. Furthermore, as set forth in claim 6, it is preferable to implement the heating and deaerating the rear plate, before the hermetically sealing. Due to the heating and deaerating, gaseous components in the rear plate may be removed. When combined with the aforementioned heating and deaerating of the faceplate, the intended degree of vacuum in the flat panel display device may be furthermore easily realized.

[0016]

In the present method for manufacturing the flat panel display device, each of the processes is implemented in a vacuum atmosphere, as further set forth in claim 7. At that time, as set forth in claim 18, it is preferable for each of the processes to be implemented in a vacuum atmosphere of 1 x 10^{-4} Pa or better. In addition, as set forth in claim 8, for instance, each of the processes may be implemented continuously and/or simultaneously, in the same manufacturing apparatus. Alternatively, as set forth in claim 9, each of the processes may be implemented, continuously and/or simultaneously, in a manufacturing apparatus that is independent for each of the processes. At this time, as set forth in claim 10, each of the manufacturing apparatuses, which is independent for each of the processes, is preferably arranged, so that the faceplate and the rear plate may not be exposed to an oxidizing atmosphere.

[0017]

In the present method of manufacturing the flat panel display device, as set forth in, for instance, claim 11, the forming the getter film on the faceplate is, more specifically, the forming the getter film essentially consisting of Ba, by depositing the Ba on the metal back layer of the faceplate, which has the phosphor layer and the metal back layer formed on the substrate, in a vacuum atmosphere. Furthermore, as set forth in claim 15, the disposing the faceplate and the rear plate faced to each other with a gap therebetween, and hermetically sealing these is, more specifically, the hermetically sealing the gap between the faceplate and the rear plate, through support frames.

[0018]

Furthermore, in the manufacturing method of a flat panel display device of the present invention, as set forth in claim 12, the getter film is preferably formed at least partially in the image display area of the faceplate. As set forth in claim 14, the getter film is preferable to be formed mainly in an area other than the phosphor layer. As set forth in claim 14, a thickness of the getter film is preferable to be 1 μm or more.

[0019]

Furthermore, in order to improve airtightness of the gap between the faceplate and the rear plate, as set forth in claim 16, the support frame and the rear plate are preferably hermetically sealed by indium (In) or/and alloy thereof. As set forth in claim 17, a region between the faceplate and the rear plate is preferably made a degree of vacuum of 1×10^{-5} Pa or better, due to a vacuum atmosphere during the aforementioned processes and the getter film. Furthermore, as set forth in claim 18, each of the processes is preferable to be implemented in a vacuum atmosphere of 1×10^{-4} Pa or better.

[0020]

The flat panel display device of the present invention, as set forth in claim 19, includes the faceplate, which has the phosphor layer and the metal back layer formed on the substrate, and the getter film, which is formed on the metal back layer and essentially consisting of Ba; and the rear plate having an electron source. In the above, the faceplate and the rear plate are disposed faced to each other so as to form a gap therebetween, and hermetically sealed.

[0021]

In the flat panel display device of the present invention, as set forth in claim 20, the getter film is preferably formed at least partially in the image display area of the faceplate. Furthermore, as set forth in claim 21, it is preferable for the getter film to be formed mainly on an area other than that of the phosphor layer on the metal back layer. As set forth in claim 22, the thickness of the getter film, essentially consisting of Ba, is preferable to be 1 μm or more. Furthermore, as set forth in claim 25, a region between the faceplate and the rear plate is preferable to be a degree of vacuum of 1×10^{-5} Pa or better.

[0022]

Furthermore, in the flat panel display device of the present invention, as set forth in claim 23, for instance, the faceplate and the rear plate are hermetically sealed through a support frame, so as to form a gap therebetween. In the flat panel display device of the present invention, as set forth in claim 24, the support frame and the faceplate are preferably hermetically sealed by means of indium or/and alloy thereof.

[0023]

The other flat panel display device of the present invention, as set forth in claim 26, is manufactured at least by depositing the getter film on the faceplate, which has the phosphor layer formed on the substrate; and disposing the faceplate, thereon the getter film is formed, and the rear plate, which has the electron source formed on the substrate, faced to each other so as to form the gap therebetween, and hermetically sealing.

[0024]

The present inventors, to cope with the problems involving the existing technology, tried to deposit the getter film without implementing flash operation of the getter material (so-called getter flash) in the device, which was difficult to implement in the existing flat panel display device. Therefrom, the present invention resulted.

[0025]

In the present invention, first, the getter film is formed on the faceplate, where the phosphor layer is formed on the substrate. Thereafter, the faceplate, thereon the getter film is deposited, and the rear plate, which has the electron source, are disposed faced to each other so as to form a gap therebetween, followed by hermetically sealing the gap. Thereby, the getter film deposition, due to depositing the evaporable gettering material, such as Ba alloy or the like, after the manufacture of the device, may be eliminated. As a result, the getter film may be suppressed from depositing on the electron source or the like, which does not require the getter film. By implementing each of the aforementioned processes in a vacuum atmosphere, the getter film, such as the Ba and so on, may be suppressed from being oxidized, and thereby the flat panel display device having the getter film, consisting of an active Ba film or the like, is manufactured.

[0026]

Each of the aforementioned processes, that is, the formation of the getter film on the faceplate and the hermetic sealing of the faceplate, which has the getter film, and the rear plate, on which the electron source is formed, may be continuously

implemented in the same manufacturing apparatus. Furthermore, a plurality of these processes may be simultaneously implemented. Thus, by implementing each of the processes in the same manufacturing apparatus, the getter film, such as Ba and so on, may be manufactured without being exposed to an oxidizing atmosphere. When the vacuum atmosphere is maintained up to the hermetic sealing so that the getter film may not be exposed to an oxidizing atmosphere, each of these processes may be implemented in the manufacturing apparatuses independent for each of the processes.

[0027]

In the present invention, specifically the Ba film is deposited on the metal back layer of the faceplate in a vacuum atmosphere. By heating Ba alloy and depositing the Ba in a vacuum atmosphere, an active Ba film may be formed. Furthermore, by depositing the Ba film before the hermetic sealing between the faceplate and the rear plate, the Ba film may be easily formed only on a predetermined position. The faceplate, on which the active Ba film like this, that is, the active getter film that does not substantially have a surface of oxide film or the like, is formed, is welded through the support frames to the rear plate, while maintaining on the vacuum atmosphere during the Ba film formation. Thus, a vacuum vessel (envelope) is formed.

[0028]

As mentioned above, the process from the deposition of the Ba film to the formation of the vacuum vessel as an envelope is implemented while maintaining the vacuum atmosphere. Thereby, without implementing the deposition of the Ba film (so called

getter flash) after the formation of the vacuum vessel, the active Ba film may be easily disposed on the metal back layer in the image display area, with good reproducibility. The getter film, substantially consisting of Ba, need only be formed at least partially in the image formation region, when the effect may be obtained.

[0029]

In addition, an extremely thin film (for instance 1μm or more) is enough for the getter film. Accordingly, when the effect on the phosphor of electrons from the electron source is not deteriorated, and thereby the brightness is not lowered, the getter film may be formed over an entire image formation region of the faceplate. In addition, in order not to lower the brightness, it is preferable for the getter film to be formed mainly on an area on the metal back layer, other than that where the phosphor layer is formed.

[0030]

According to the aforementioned manufacturing method of the present invention, the gap between the faceplate and the rear plate of the flat panel display device may be evacuated to a degree of vacuum of 10^{-5} Pa or better. Thereby, even in a display device of large size screen, a uniform image may be obtained.

[0031]

The present flat panel display device has the active getter film, which is formed only on a predetermined position and made essentially of Ba. Accordingly, during manufacture or use of the display device, problems may be suppressed from occurring that short circuit of wiring and so on may be caused due to sticking

of the getter film, consisting of Ba, onto a position such as the electron source or the like that does not requires the getter film. Furthermore, a function as the getter film does not deteriorate during manufacture or use of the display.

[0032]

As a result, according to the flat panel display device that has the getter film consisting of such the active Ba film, a degree of vacuum of 10^{-5} Pa or better, which is required to obtain sufficient electron emissivity, may be obtained with reproducibility, and furthermore such a vacuum state may be maintained over a long period.

[0033]

Furthermore, according to the manufacturing method and the flat panel display device of the present invention, since the hermetic sealing is implemented in a vacuum atmosphere, exhausting and vacuuming, which are necessary after the manufacture of the conventional flat panel display device, become unnecessary. Accordingly, a configuration for exhausting (such as tubing for exhausting, for instance), furthermore an exhausting device, which are indispensable in the existing display device, are made unnecessary. Furthermore, since the tubing for the exhausting may be dispensed with, exhaust conductance may be made larger, and exhaust efficiency of the flat panel display device is made of high quality.

[0034]

Since the present flat panel display device is manufactured on the basis of the aforementioned manufacturing method of the present invention, the flat panel display device having the

aforementioned effects may be obtained.

[0035]

[Mode for Carrying Out the Invention]

In the following, modes for implementing the present invention will be explained.

[0036]

First, a mode of a manufacturing method of a flat panel display device of the present invention will be explained with reference to Figs. 1A, 1B and 1C. As shown in Fig. 1A, first, a faceplate 10, a rear plate 20, and support frames 30 are prepared as usual.

[0037]

The faceplate 10 includes a phosphor layer 12 formed on a transparent substrate, such as a glass substrate 11. The phosphor layer 12, in the case of a color picture tube, includes a red emitting phosphor layer, a green emitting phosphor layer, and a blue emitting phosphor layer, which are formed corresponding to pixels. In between, black conductive material 13 is disposed to separate the phosphor layers. The phosphor layers 12, which emit in the respective colors of red, green, and blue, and the black conductive material 13 separating therebetween are repeatedly formed in turn in a horizontal direction. An area where the phosphor layers 12 and the black conductive material 13 exist constitutes an image display area.

[0038]

The black conductive material 13, according to its shape, is called black stripe, black matrix, or the like. In a black stripe type phosphor film, phosphor stripes of each of red, green,

and blue colors are formed in turn, and stripe-like black conductive material separates therebetween. In a black matrix type phosphor film, phosphor dots of each of red, green, and blue colors are arranged in lattices, and the black conductive material separates therebetween. Various methods for arranging the phosphor dots may be applied.

[0039]

On the phosphor layers 12, a metal back layer 14 is formed. The metal back layer 14 is made of a conductive thin film, such as an Al film, and reflects light, which proceeds toward a direction of the rear plate 20, which becomes an electron source, among light emitted in the phosphor layers 12, and thereby improves the brightness. Furthermore, the metal back layer 14 gives conductivity to the image display area of the faceplate 10, thereby suppresses electricity from building up there, and plays a role of an anode electrode with respect to the electron source of the rear plate 20. The metal back layer 14 also has a function of suppressing ions from damaging the phosphor layer 12, the ions being generated by ionizing gases remaining in the faceplate 10 and the vacuum vessel (envelope) by the action of an electron beam.

[0040]

As the formation method of the phosphor layers 12 and the black conductive material 13 on the glass substrate 11, slurry method or printing method may be applied. After the formation of the phosphor layers 12 and the black conductive material 13 on the glass substrate 11, a conductive thin film, consisting of an Al film of a thickness of, for instance, 2,500 nm or less, which depends on an anode voltage or the like, is formed further thereon,

by means of vacuum deposition method or sputtering method. Thereby, the metal back layer 14 is formed.

[0041]

The rear plate 20 includes a number of electron emitters 22 formed on a substrate 21, which is made of an insulating substrate such as glass substrate or ceramic substrate, or Si substrate. These electron emitters 22 are provided with, for instance, field emission cold cathodes (emitters) or surface conduction electron emitters. On a formation surface of the electron emitters 22 of the rear plate 20, wiring (not shown) is disposed. That is, the number of electron emitters 22 are formed in matrix corresponding to the phosphors of the individual pixels, and the mutually crossing wiring (X-Y wiring) is disposed and drives the matrix electron emitters, line by line.

[0042]

The support frames 30 hermetically seal a space between the faceplate 10 and the rear plate 20. The support frames 30 are welded to the faceplate 10 and the rear plate 20 by the use of frit glass or indium or alloys thereof. Therefrom, the vacuum vessel as the envelope described below is constituted. The support frames 30 are provided with signal-inputting terminals and row selection terminals (not shown). These terminals correspond to cross wiring (X-Y wiring) of the rear plate 20.

[0043]

In the case of the flat panel display device being large in size, since the present device is thin and tabular, in order not to cause bending or the like, and in order to endow mechanical strength against atmospheric pressure, reinforcement plates 50

(atmospheric pressure supporting member, spacer) may be disposed according to appropriately intended strength, such as shown in, for instance, Fig. 2.

[0044]

The faceplate 10, the rear plate 20 and the support frames 30 as described above are prepared. Thereafter, processes from depositing the getter film to the formation of the vacuum vessel as the envelope (welding of the support frames 30 and the faceplate 10 and the rear plate 30) are implemented while maintaining a vacuum atmosphere. For such a sequence of processes, a vacuum treatment apparatus 100, such as shown in for instance Fig. 3, may be used.

[0045]

The vacuum treatment apparatus 100 shown in Fig. 3 includes a load chamber 101 for loading a faceplate 10, a heating and deaerating chamber 102, a cooling chamber 103, a deposition chamber 104 for vapor depositing a getter film, a load chamber 105 for loading a rear plate 20 and a support frame 30, a heating and deaerating chamber 106, a cooling chamber 107, a assembly chamber 108 for assembling the faceplate 10 and the rear plate 20, a heat treatment chamber 109 for welding the support frames 30 to the faceplate 10, a cooling chamber 110, and an unload chamber 111. The individual chambers are treatment chambers where vacuum treatment can be implemented, and these treatment chambers are connected therebetween by means of gate valves or the like.

[0046]

The faceplate 10, which is formed up to the metal back layer 14, is disposed in the load chamber 101. At the end portion of

the faceplate 10, as shown in Fig. 4, for instance, a groove 32 is formed. In order to seal hermetically the groove 32 and the support frame 30, welding material 31 such as indium or alloys thereof is disposed in advance in the groove 32. Then, after an atmosphere in the load chamber 101 is evacuated to be a vacuum atmosphere, the faceplate 10 is sent into the heating and deaerating chamber 102.

[0047]

In the heating and deaerating chamber 102, the faceplate 10 is heated to a temperature from 300 to 320°C for instance, and thereby the faceplate 10 is deaerated. Indium (alloy thereof) 31 is disposed in advance in the groove 32 at the end portion of the faceplate 10. Accordingly, in order for In (alloy thereof) not to drop from the groove 32 after melting due to heat in the heating and deaerating, the faceplate is preferably disposed at a bottom portion of the heating and deaerating chamber 102 with the groove 32 directed upward.

[0048]

The faceplate 10, which has undergone the heating and deaerating, is transferred into the cooling chamber 103, and is cooled there down to a temperature of for instance 100°C or less (for instance 80 to 100°C). The cooled faceplate 10 is sent into the deposition chamber 104 of the getter film. In the vapor deposition chamber 104 of the getter film, as shown in Fig. 1B for instance, an active Ba film 15 is vapor deposited as the getter film on the metal back layer 14.

[0049]

That is, first, in the vacuum treatment chamber 104, a

getter device 16 is disposed in a position that faces the metal back layer 14 of the faceplate 10. The getter device 16 is configured such that getter material 16b is filled in an annular getter container 16a, which has an opening at one end, for example. The getter container 16a is composed of metal member, such as stainless steel, for instance, and therein 16a like this the getter material 16b is filled under pressure by means of a press machine or the like. Alternatively, the getter device may be configured such that the getter material is filled in a long container with a U-shaped section. That is, the configuration thereof is not particularly restricted.

[0050]

For the getter material 16b, evaporable getter material may be used, for instance. As a specific example of the evaporable getter material, mixed powder of from 40 to 60% by weight of Ba-Al alloy powder and from 60 to 40% by weight of Ni powder, or the like can be cited. In addition, as needs arise, 2.0% by weight or less of nitride powder such as iron nitride powder may be added. As the Ba-Al alloy, $BaAl_4$ alloy is used, for instance. The Ba-Al alloy powder and Ni powder may be granulated in advance the use. At this time, all of the Ba-Al alloy powder and the Ni powder may be granulated, or part thereof may be granulated.

[0051]

The getter device as mentioned above is heated from the outside by means of an induction heating apparatus or the like, and thereby Ba is caused to flash into a vacuum atmosphere (getter flash). In the case of the mixture of the $BaAl_4$ alloy powder and the Ni powder being used as the getter material 16b, once these

are heated up to approximately 700°C, a temperature keeps ascending up to approximately 1000°C due to self-heating. Then, based on the following reaction equation

$BaAl_4 + 2Ni \quad Ba + 2Al_2Ni$,

Ba is flashed and deposited on the metal back layer 14 of the faceplate 10.

[0052]

In order for the Ba film 15 deposited on the metal back layer 14 not to be contaminated from oxygen or carbon, the Ba is preferably flashed in the vacuum treatment chamber (the vapor deposition chamber) 104 that is evacuated down to 1×10^{-4} Pa or better, for instance. By implementing the getter flash under the vacuum atmosphere like this, the Ba film 15 extremely effective as the getter film, that is, the substantially active Ba film 15 that is not contaminated from oxygen or carbon, may be obtained.

[0053]

Since the getter material, such as Ba-Al alloy, for forming the aforementioned Ba film is used to flash the Ba film by heating, there is no particular restriction on impurities contained therein. A total content of carbon, oxygen, and nitrogen, however, is preferable to be 0.4% by weight or less. This is because when the getter material, of which amount of the aforementioned impurities is reduced, is used, reactivity of powder of the getter material, such as Ba-Al alloy or the like, may be remarkably improved. More specifically, it is preferable that a content of carbon is 0.04% by weight or less, that of oxygen being 0.35% by weight or less, that of nitrogen being 0.01% by weight or less. In particular, carbon promotes a reaction together with moisture

in the air, and causes to deteriorate performance as the getter material. Accordingly, the content of the carbon is more preferable to be 0.02% by weight or less.

[0054]

Furthermore, from a viewpoint of causing the reaction of the getter material to occur homogeneously over the whole, particle diameters of these getter material powders are preferable to be 45 μm or less for the Ba-Al alloy powder and to be 10 μm or less for Ni powder, for instance. In addition, the Ba film obtained from the above getter materials is substantially free from impurities, due to the formation through flashing of the Ba-Al alloy. However, in order to obtain an effect as the getter film, the purity thereof is preferable to be 100.

[0055]

When the effect of the getter film is obtained, the Ba film 15 active as the getter film need only be formed at least partially in the image formation area of the metal back layer 14. When the brightness is not deteriorated, the Ba film 15 may be deposited on an entire surface of the metal back layer 14. When the phosphor layer 12 is separated by the black conductive material (black stripe, black matrix and so on) 13 as mentioned above, it is also effective to selectively deposit mainly on a portion corresponding to an upper portion of the black conductive material 13, alternatively, on a region other than the phosphor layer 12. By selectively depositing the Ba film 15 on the black conductive material 13, the electrons, which impinge on the phosphor layer, may be prevented from being absorbed, and thereby deterioration in brightness may be suppressed from occurring.

[0056]

When the Ba film 15 is selectively deposited on the black conductive material 13, a mask having an appropriate aperture pattern may be aligned and fixed on, for instance, the metal back layer 14, and through the mask, the Ba is flashed (getter flash). At this time, since the Ba film 15 is deposited on the metal back layer 14, which also works as an anode electrode, there is no need of particularly strictly patterning. That is, a portion overlapping on the phosphor layer 12, if occurred, does not cause problems.

[0057]

In view of obtaining an effect as the getter film, the thickness of the active Ba film 15 is preferable to be 1μm or more, more preferable to be in the range from 10 to 100 μm. More specifically, when the active Ba film 15, which is not contaminated from oxygen or carbon, is deposited with a thickness of for instance 1 μm or more, it may exhibit a sufficient getter function and evacuate the inside of the envelop to a high vacuum state.

[0058]

Next, while maintaining surface activity of the aforementioned Ba film 15, as shown in Fig. 1 (c), the faceplate 10 and the rear plate 20 are welded through the support frames 30. In welding the support frames 30 to the faceplate 10 and the rear plate 20, first the faceplate 10, thereon the getter film has been deposited in the vapor deposition chamber 104 shown in Fig. 3, is sent into the assembly chamber 108.

[0059]

Meanwhile, the rear plate 20, in which the electron sources are formed on the substrate, and the support frames 30 are preferable to be fixed before disposing in the load chamber 105, because the process is easy. After the atmosphere in the load chamber 105 is evacuated to a vacuum atmosphere, the rear plate 20 and the support frames 30 are sent into the heating and deaerating chamber 106.

[0060]

In the heating and deaerating chamber 106, the rear plate 20 and the support frames 30 are heated at a temperature, for instance, from 300 to 320°C to deaerate the rear plate 20. Then, the rear plate 20 and the support frames 30, which have been heated/deaerated, are sent into the cooling chamber 107 and cooled down to a temperature of, for instance, 100°C or less (for instance 80 to 100°C). Similarly as the aforementioned faceplate 10, the cooled rear plate 20 and support frames 30 are sent into the assembly chamber 108.

[0061]

The inside of the assembly chamber 108 is evacuated to a vacuum atmosphere similar as that of the vapor deposition chamber 104. Specifically, the inside of the assembly chamber 108 is preferable to be evacuated to 1×10^{-4} Pa or better similarly as the vapor deposition chamber 104. When the faceplate 10, the rear plate 20 and the support frames 30 are assembled (aligned) under such vacuum atmosphere, the Ba film 15 formed in the deposition chamber 104 may maintain an active state. That is, the surface of the Ba film 15 can be suppressed from being contaminated from oxygen or carbon.

[0062]

In assembling, as needs arise, reinforcement plates (not shown) may be disposed between the faceplate 10 and the rear plate 20. When the flat panel display device is large in its size, due to thinness thereof, the device tends to bend. Accordingly, in order for the device not to bend, and in order to endow strength against atmospheric pressure, the reinforcement plates (atmospheric pressure sustaining member, spacers) 50 shown in, for instance, Fig. 2 may be preferably disposed in conformity with an appropriately intended strength.

[0063]

In such a state, a body assembled in the above is further sent into the heat treatment chamber 109, which is evacuated to the similar vacuum atmosphere, for instance 1 x 10^{-4} Pa or better. In the heat treatment chamber 109, heat-treatment is implemented at a temperature according to the welding material 31 being used, and the faceplate 10 and the rear plate 20 are welded through the support frames 30 under pressure. As needs arise, activation of the electron source or the like may be carried out in advance.

[0064]

When indium (or alloys thereof) is used as the welding material 31, it is heated at a temperature of approximately 100°C to weld. When pressing during the welding, in order to attain a further sufficient welding, ultra-sonic waves can be preferably applied at least to the welding portion. Since indium (or alloys thereof) 31 is previously disposed in the groove 32 at the end of the faceplate 10, the indium (or alloy thereof) is liable to drop from the groove 32 after melting due to heating during the

welding. Accordingly, in order for the indium (or alloys thereof) not to drop from the groove 32, the faceplate 10 is preferably disposed at the bottom portion in the heat treatment chamber 109 with the groove 32 directed upward. Thereafter, the rear plate 20, on which the support frames 30 is fixed, is disposed from above and welded with the faceplate 10.

[0065]

In general, the indium (or the alloy thereof) is said to be insufficient in its joining strength. However, in the flat panel display device of the present invention, since the gap between the faceplate 10 and the rear plate 20 is maintained in a vacuum state, owing to the atmospheric pressure, with the indium (or the alloy thereof) alone, sufficient strength may be obtained. When enhancing the bonding strength further more than that due to the indium (or the alloy thereof), the welding portion may be reinforced by means of epoxy resin or the like.

[0066]

Thus, from the faceplate 10, the rear plate 20, and the support frames 30, the vacuum vessel as the envelope is formed. That is, by hermetically sealing the gap between the faceplate 10 and the rear plate 20 through the support frames 30, a flat panel display device 40 is manufactured. Thereafter, the flat panel display device 40 is cooled in the cooling chamber 110 down to room temperature, and is taken out of the unload chamber 111.

[0067]

The vacuum treatment chamber 100 used for manufacturing the flat panel display device 40 may be an apparatus in which the individual configurations from the load chamber 101 to the unload

chamber 111 are combined. The configuration thereof may not be particularly restricted as far as a vacuum atmosphere is maintained.

[0068]

Of the manufacturing processes of the aforementioned flat panel display device 40, from the vapor deposition of the Ba film 15 as the getter film to the manufacture (welding) of the vacuum vessel as the envelope is implemented in a vacuum atmosphere. Accordingly, the active Ba film 15, which is formed in the deposition chamber 104, may be disposed in the hermetically sealed envelope as it is, without being contaminated from oxygen or carbon.

[0069]

Thus, the present flat panel display device 40, which has the active Ba film 15 formed on the metal back layer 14, may be obtained. That is, first the active Ba film 15 is formed in advance on the metal back layer 14 located in an image display region. Then, while maintaining the active surface thereof 15, the faceplate 10 and the rear plate 20 are welded through the support frames 30. Thereby, the flat panel display device 40, in which the active Ba film 15 is disposed at a predetermined position in the envelope as the getter film, is formed.

[0070]

According to such the flat panel display device 40, a vacuum state of 1 x 10^{-5} Pa or better, which is necessary for obtaining sufficient electron emissivity, furthermore a still higher vacuum state of 1 x 10^{-6} Pa or better, may be obtained at an initial stage with good reproducibility. This may be obtained by means of the

vacuum atmospheres during each of the aforementioned processes and the active Ba film 15 as the getter film. In addition, since the active Ba film 15 is formed on the entire image display region, the aforementioned degree of vacuum may be uniformly attained an envelope as a whole of the flat panel display device 40.

[0071]

Furthermore, in the manufacturing process of the aforementioned flat panel display device 40 of the present invention, since the hermetic sealing is implemented in the vacuum atmosphere, after the manufacture of the flat panel display device, the process for exhausting and vacuuming the inside of the device become unnecessary. Accordingly, a configuration for exhausting (such as for instance tubing for exhaust) that is indispensable in the existing apparatus, furthermore an exhausting apparatus, become unnecessary. In addition to this, due to the disuse of the tubing for exhausting, exhaust conductance becomes larger, and exhaust efficiency of the flat panel display device becomes extremely excellent.

[0072]

Furthermore, when operating the flat panel display device 40, even if gaseous components were liberated from the electron emitter 22 or the other periphery member thereof, these gaseous components would be instantaneously absorbed by the active Ba film 15 formed over the entire image display region, that is by the active Ba film 15 excellent in a function as the getter film. As a result, according to the flat panel display device 40 of the present invention, the degree of vacuum as mentioned above may be maintained over a long period. In the present flat panel

display device 40, the degree of vacuum of for instance 10^{-5} Pa or better may be maintained for more than 1000 hr.

[0073]

Furthermore, since the Ba film 15 is formed in the manufacturing process of the faceplate 10, the active Ba film 15 may be easily deposited only on the necessary position in the image display region. For instance, even in the case of disposing the reinforcement plates between the faceplate 10 and the rear plate 20, such an inconvenience is not caused as that the Ba film sticks to the reinforcement plates and short-circuit the cathode (electron emitter 22) and the anode (metal back layer 14). This is different from the case where the getter is flashed after the manufacture of the envelope.

[0074]

Furthermore, since the active Ba film 15 is deposited in advance in the course of manufacture of the faceplate 10, irrespective of a magnitude of the faceplate 10, the active Ba film 15 may be easily deposited on a necessary position in the image display region. That is, not only the inside of the envelope may be excellently and uniformly maintained in a high vacuum state, but also such vacuum state may be stably maintained over a long period.

[0075]

The flat panel display device 40 as mentioned above may be used in TV display, which is based on TV signals according to, for instance, the NTSC system. At that time, through signal inputting terminals, row selection terminals, and furthermore through a high voltage terminal, all of which are omitted from

showing in the figure, the flat panel display device is connected to an external electrical circuit. When indium or alloy thereof that is conductive is used as the welding material 31, the welding material 31 may be used as the terminal.

[0076]

To the individual terminals, scanning signals are inputted to sequentially drive line by line the electron sources, which are disposed on the flat panel display device 40, that is the electron emitters 22 wired in matrix of M row by N column. Furthermore, modulation signals are inputted to modulate an output electron beam of the selected one line of the electron emitters 22. To the high voltage terminal, an accelerating voltage is applied to give the electron beam, which is emitted from the electron emitter 22, energy sufficient to excite phosphor.

[0077]

In the present flat panel display device 40 thus configured, electrons are caused to emit by applying a voltage to the individual electron emitters 22 through the terminal. Furthermore, a high voltage is applied through the high voltage terminal to the metal back layer 14, and thereby the electron beam is accelerated. The accelerated electrons impinge onto the phosphor layer 12, and thereby the phosphor layer 12 is caused to emit, resulting in the formation of the images.

[0078]

The flat panel display devices of the present invention may be used for various kinds of display devices, such as, for instance, display devices of TV receivers or computer terminals.

[0079]

[Embodiments]

In the following, concrete embodiments of the present invention and evaluation results thereof will be explained.

[0080]

Embodiment 1

First, in the vapor deposition chamber 104 of the vacuum treatment apparatus 100 shown in Fig. 3, the faceplate, thereon up to the metal back layer is formed, is set at a bottom portion thereof. At the same time, at a position of a top portion thereof 104, which faces the metal back layer, the getter device is disposed. For the getter device, one, in which getter material of 300 mg is filled in an annular stainless steel getter container with one open end, is used. Here, the getter material contains 48.5% by weight of $BaAl_4$ alloy powder, 50.5% by weight of Ni powder, and 1.0% by weight of iron nitride powder. The inside of the vapor deposition chamber 104 is evacuated to a degree of vacuum of 2 x 10^{-4} Pa.

[0081]

Next, the aforementioned getter device is heated by means of an induction heater from the outside, and thereby Ba is flashed (getter flash). Due to the getter flashing, the active Ba film of a thickness of approximately 10 μm is deposited on the metal back layer.

[0082]

Next, while maintaining the aforementioned vacuum atmosphere, the faceplate and the rear plate thereon the support frames are fixed, are assembled (aligned) in the assembly chamber

106. Thereafter, in the heat treatment chamber 109, which is evacuated to the similar degree of vacuum as the above, while continuing evacuation, the faceplate and the rear plate are heat-treated at 100°C, and thereby welded through the support frames.

[0083]

When the degree of vacuum inside the vacuum vessel (envelope) of thus obtained flat panel display device is measured, it is found that a sufficient degree of vacuum is achieved. The degree of vacuum is a value obtained uniformly in the respective portions in the vacuum vessel (envelope). According to the flat panel display device like this, excellent image performance can be obtained. Furthermore, after this flat panel display device had been operated for 1000 hr, under conditions of room temperature and rated operation, the degree of vacuum inside the vacuum vessel (envelope) was measured and found that the sufficient degree of vacuum is maintained even after the operation.

[0084]

Meanwhile, as comparative example 1 of the present invention, a display device is manufactured such that a Ba-Al alloy film is deposited in the place of the getter film consisting of Ba of the aforementioned flat panel display device of Embodiment 1. In the flat panel display device of this comparative example 1, it is found that, immediately after the manufacture, a sufficient degree of vacuum, which is the same as that during the hermetic sealing, is maintained. However, when operating the display device, an electron beam from the electron

source impinged upon the Ba-Al alloy film and generated gases, thereby a driver was damaged and lighting failure was caused due to voltage-breakdown inside the display device. As a result, the above device could not be used as the flat panel display device.

[0085]

Furthermore, as comparative example 2, a display device is manufactured such that a Ti-Al alloy film is deposited in the place of the getter film made of Ba, which is used in the flat panel display device of Embodiment 1. In the flat panel display device of this comparative example 2, immediately after the manufacture, a sufficient degree of vacuum, which is the same as that during the hermetic sealing, was maintained. However, when operated for 100 hr similarly as Embodiment 1 under the conditions of room temperature and rated operation, brightness lowering occurred. When measuring the degree of vacuum inside the vacuum vessel (envelope), it is confirmed that the degree of vacuum is deteriorated and a sufficient gettering effect may not be obtained. As a result, the life thereof was short.

[0086]

Still furthermore, as comparative example 3, a flat panel display device is manufactured such that the getter device is disposed at an end portion of the envelope other than the display region. When measuring the degree of vacuum inside the vacuum vessel (envelope) of the display device of the comparative example 3, a portion close to the getter device was found to have sufficient brightness, in other words, the sufficient vacuum was maintained. However, there was not found light emission in the center of the vacuum vessel, that is, the sufficient vacuum was not maintained.

Such state was the same even after the display device was operated for 100 hr similarly as Embodiment 1, under the conditions of room temperature and rated operation.

[0087]

[Effects of the Invention]

As explained above, according to the method for manufacturing a flat panel display device of the present invention, the Ba film of excellent getter function may be easily disposed in the image display region in the vacuum vessel with good reproducibility, while maintaining the activity of the surface of the Ba film. Furthermore, according to the flat panel display device of the present invention, since the inside of a vacuum vessel as an envelope may be maintained in a high vacuum state over a long period, excellent image characteristics and device characteristics may be obtained.

[Brief Explanation of the Drawings]

[FIG. 1] Figs. 1A, 1B and 1C are sectional views schematically showing essential manufacturing processes of a flat panel display device according to one embodiment of the present invention, and a rough configuration of the flat panel display device according to one embodiment of the present invention.

[FIG. 2] Fig. 2 is a sectional view schematically showing a rough configuration of the flat panel display device according to another embodiment of the present invention.

[FIG. 3] Fig. 3 is a diagram showing one configuration example of a vacuum treatment apparatus used in manufacturing the flat panel display device of the present invention.

[FIG. 4] Fig. 4 is a sectional view showing in enlargement

one configuration example of an end portion of a faceplate of the flat panel display device of the present invention.

[Explanation of the Numerals]

10... ... faceplate

11... ... glass substrate

12... ... phosphor layer

14... ... metal back layer

15... ... active Ba film

16... ... getter device

20... ... rear plate

22... ... electron emitter

30... ... support frame

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